

ASSESSING THE EFFECTIVENESS OF THE STIRRUP, HORSESHOE, HEEL-
LOCK, AND FIGURE-8 COMPONENTS OF THE CLOSED BASKET-WEAVE
ANKLE TAPING METHOD IN VARIOUS COMBINATIONS.

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DEDICATION

I would like to dedicate this to my fiancé Jacob, who was always there to support me and lend an ear with things became difficult. Jacob, you were everything I needed and more throughout this journey and I thank you for it. I would also like to dedicate this to the strongest and most motivational woman I know, my mother. Mom, you have always taught me to be strong and pushed me to achieve my goals, without your love and support I would not be where I am today. Thank you!

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ABSTRACT

The purpose of this study was: 1.) to assess the effectiveness of the four individual components of the closed basket-weave ankle taping method (stirrups, horseshoes, heel-locks, figure-8's) in limiting range of motion immediately following application; 2.) to determine which combination of the four individual components was most effective for limiting range of motion immediately following application. Twenty healthy participants (8 males/12 females, 19.8 ± 1.7 years, height = 172.5 ± 10.3 cm, weight = 70.0 ± 12.7 kg) from a large Midwestern University volunteered for this study. An ankle electrogoniometer was used to measure ankle range of motion in all four directions (eversion, inversion, dorsiflexion, plantarflexion). All testing took place in one session and used the participants' dominant leg. Prior to testing, the participants' leg was cleaned, shaved, and free of open wounds. Initially, range of motion was measured for all four motions in the no tape condition. Then each of the 8 tape conditions was applied to the ankle in a counterbalanced order. After each tape application range of motion was re-tested. Testing was concluded with a final range of motion measurement in the no tape condition. Three trials were taken for each of the four motions; the mean of the three trials was used for analysis. A paired samples t-test was conducted on the beginning and ending no tape measurements to determine if a natural increase in ankle range of motion occurred over the testing session. Four separate repeated measures ANOVAs were conducted for each range of motion to determine a difference between the 9 taping conditions. The results indicated a significant decrease in ankle range of motion with the application of tape when compared to the no tape range of motion value. It was found that the stirrup (SU), heel-lock (HL), and figure-8 (F8) components of the closed basketweave ankle taping

method significantly restricted inversion, dorsiflexion, and plantarflexion. On the contrary it was found that the horseshoe (HS) component did not significantly restrict ankle range of motion for any of the four ranges of motion. Further interpretation of results showed that the HL/F8 combination was as effective as the SU/HL/F8 and the CBW taping combinations. The findings of this research indicate that the horseshoe component could be removed from the closed basketweave ankle taping method due to its inability to effectively restrict ankle range of motion. Furthermore, the findings of this research indicate the HL/F8 ankle taping method is equally as effective as the three component taping method (SU/HL/F8) and the full, four component closed basketweave.

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INTRODUCTION

Struggling with ankle instability as a result of a current or previous ankle injury is an issue faced by many athletes at some point throughout their careers. Ankle sprains are among the most common injuries sustained by athletes, with lateral or inversion ankle sprains being the most common.¹⁻⁵ Lateral ankle sprains cause damage to the ankle's lateral soft tissue structures including, but not limited to, the anterior and posterior talofibular ligaments and the calcaneofibular ligament.^{1, 3-7}

Athletes of both the elite and amateur levels suffer from ankle injuries of some degree.^{1, 5, 8} Athletes of the 2004 Athens Olympics reported ankle sprains as their second most common ankle injury falling second to Achilles tendon pathologies.⁵ Even athletes at the high school level have reported ankle sprains as one of the most common injuries sustained in athletics.¹ Surveys from a hundred high schools found that ankle sprains accounted for the majority of the total injuries sustained in one competition year and occurred most often in sports that required large amounts of cutting, jumping, and quick changes in direction.¹

Depending on the severity of the ankle sprain and the structures damaged, athletes may be withheld from practice and/or competition for days or weeks to provide adequate healing time.^{1, 8} When returning to play many clinicians use a prophylactic device such as adhesive taping or bracing to help decrease the likelihood of further injury or re-injury to the affected joint. Prophylactic taping or bracing has been proven effective in reducing the occurrence of ankle sprains⁹⁻¹¹ as well as providing mechanical restraint against unwanted excessive forces.^{9, 11} Often times, due to the preference of the athlete and/or supplies available, prophylactic taping is selected as the device of choice.

Both clinically and in published research,¹²⁻²⁰ the closed basket-weave taping method is consistently used.

The closed basket-weave taping technique consists of four individual components: horseshoes, stirrups, heel-locks, and figure-8's and is regarded by most athletic training texts as the gold standard of ankle taping. The premise behind the components of the closed basket-weave is that each component contributes to creating an environment that is optimal for the stability of the ankle joint. Depending on personal preference of the clinician, the order of the individual taping components may vary. For example, some clinicians apply the stirrup and horseshoe components in a basket-weave formation while others apply the stirrups followed by the horseshoes. The number of each component used also varies among clinicians.

Although the closed basket-weave is the method of choice, little research exists regarding the effectiveness of each component of this taping technique. Rarick et al²⁰ looked at the effectiveness of the basketweave taping method, in three different combinations, for reducing range of motion. They found that each added component further aided in reducing range of motion.²⁰ Minimal research has been conducted on the individual components of the closed basketweave and no research has looked specifically at the effectiveness of each individual component of the closed basket-weave alone. Therefore, the purpose of this study was to: 1.) assess the effectiveness of the four individual components of the closed basket-weave ankle taping method (stirrups, horseshoes, heel-locks, figure-8's) in limiting range of motion immediately following application; and 2.) to determine which combination of the four individual

components was most effective for limiting range of motion immediately following application

METHODS

Subjects

This study included twenty healthy, injury free participants (8 males/12 females, 19.8 ± 1.7 years old, height = $172.5\text{cm} \pm 10.3\text{cm}$, weight = $70.0\text{kg} \pm 12.7\text{kg}$) who volunteered for this study. Subject inclusion criteria required that the subjects partake in cardiovascular activity for 30 minutes at least three times per week, were injury free in the lower leg and ankle complex the 6 months prior to the beginning of testing and free of the following symptoms at time of testing: discoloration, swelling, and/or decreased range of motion. An injury was defined as any damage to the soft tissue and/or bony structures of the lower leg and/or ankle complex.

Participants were excluded from this study if they had an allergy to the adhesive properties of the materials used, if they arrived on testing day with open wounds or abrasions in the testing area, or if they had surgery to the ankle, foot or lower leg. Before participating in the study, all subjects read and signed an informed consent form approved by the University's Institutional Review Board for the Protection of Human Subjects, which also approved this study.

Instrumentation

Each subjects' ankle range of motion was measured using an ankle electrogoniometer (Figure 1). This device was used in previous research evaluating ankle range of motion.²¹ The goniometer measured the participant's uniplanar ankle

range of motion in degrees (°). Other supplies used during this study included foam pre-wrap (Mueller, Prairie Du Sac, WI), adhesive tape spray (Super Tape Adherent, San Antonio, TX), heel and lace pads with skin lube (Mueller, Prairie Du Sac, WI), and 1 ½ inch athletic tape (Zonas Athletic Tape, Johnson & Johnson Products, Inc., New Brunswick, NJ).

Procedures

All data were collected during a single testing session. Participants were asked to come dressed in shorts to ensure exposure of the lower leg and ankle throughout testing session. All testing was completed on the participant's dominant leg which was defined as the leg the participant reported was used to kick a ball. Prior to testing, the participant's leg was cleaned with isopropyl alcohol and dried. They were also asked to have their leg shaved beginning at the base of the gastrocnemius down to the base of the metatarsals. Prior to range of motion testing the participants completed a ten minute warm-up on a stationary bike. The participants were asked to maintain a speed between 50 and 60 rpm throughout the duration of the warm-up.

Range of Motion Testing

Each participant was asked to lay supine on the exam table with their dominant leg extended and their non-dominant leg resting comfortably. The foot of the dominant leg was placed into the electrogoniometer following the protocol described in a previous study.²¹ To combat possible knee and hip motion the limb was secured into the apparatus through the Velcro straps placed around the lower leg directly above the

malleoli, across the distal foot, and a third strap secured the upper thigh to the table to help combat the use of the hip in ankle movements. Once the participant was secured to the device the researcher (JP) identified subtalar neutral by palpating the dome of the talus²² for talonavicular congruency.²³ Once subtalar neutral was established the ankle electrogoniometer was zeroed.

Participants were given two practice trials in the ankle electrogoniometer to familiarize themselves with the apparatus as well as to acquaint themselves with properly completing the motions of the ankle. During these practice sessions the participants were untaped. Participants were instructed to move their foot into maximal inversion, eversion, plantarflexion, and dorsiflexion. The order in which the motions were completed was randomized between participants. Ankle range of motion for inversion, eversion, plantarflexion, and dorsiflexion was measured three times for each condition.

Taping Conditions

Testing began with a no tape condition, followed by the application of 8 tape conditions in counterbalanced order, and finished with a second no tape condition. The two no tape conditions were completed to evaluate whether a natural increase in ankle range of motion occurred from the beginning of the testing session to the end of the testing session. All taping conditions were applied by the same investigator (JP). For all the tape conditions, cloth athletic tape, heel and lace pads, foam pre-wrap, and adhesive tape spray were used. Prior to the tape application the ankle was placed into maximal dorsiflexion. Next two heel and lace pads were placed over the heel and lace areas of

the ankle followed by a thin layer of adhesive tape spray. Then a single layer of foam pre-wrap was placed in a circular pattern from the base of the metatarsals to the base of the gastronemius followed by two anchor strips, one at the base of the gastrocnemius and another at the base of the metatarsals. Then each tape condition was applied. An explanation of each tape conditions is included in Table 1.

Once the taping condition was applied the participant's ankle range of motion was re-tested in the same manner as previously described. Following each range of motion measure, the participant was then given a four minute break at which time the tape was removed and the skin was cleaned with isopropyl alcohol, and the next taping combination was applied. This process was repeated until all conditions were tested. Between each application participants were reminded to give maximal effort with each range of motion attempt.

Statistical Analysis

The means of the 3 range of motion trials in each of the four directions (eversion, inversion, dorsiflexion, plantarflexion) were used for statistical analysis. A paired samples t-test was conducted on the means of the beginning and ending no tape values. Four separate repeated measure analysis of variances (ANOVA) were conducted on the means of 9 taping conditions: beginning no tape, horseshoes (HS), heel-lock (HL), stirrup (SU), figure-8's (F8), stirrup/horseshoes (SU/HS), heel-locks/figure-8's (HL/F8), stirrups/figure-8's/heel-lock (SU/F8/HL), closed basket-weave (CBW), one for each direction (eversion, inversion, dorsiflexion, and plantarflexion). A Tukey post hoc was conducted on any significant findings. A priori alpha level was set at $p < .05$.

RESULTS

Means and standard deviations for all data are located in Table 2. The results of the paired samples t-test showed no significant difference between the two no tape range of motion measurements in any direction, inversion $t_{18} = 1.93$, $p = .07$; eversion $t_{18} = -1.37$, $p = .19$; dorsiflexion $t_{18} = -.23$, $p = .82$; plantarflexion $t_{18} = .32$, $p = .76$. No significant difference between beginning and end indicates there was no natural increase in ankle range of motion due to repeated testing. Results for the repeated measure analysis of variance are reported in the following paragraphs.

Inversion

The results of the repeated measures ANOVA for ankle inversion identified a significant difference among the 9 taping conditions. ($F_{8,152} = 28.40$, $P=.01$). Results of the Tukey post hoc test identified a significant difference between the no tape range of motion value and three of the individual taping components: stirrups, heel-locks and figure-8's. Of the four individual components, stirrups and heel-locks are responsible for the greatest restriction of inversion range of motion. (Figure 3) Furthermore a significant difference was identified between no tape range of motion value and the following taping combinations: SU/HS, HL/F8, SU/HL/F8, and CBW. (Figure 4) Significant findings were also identified between the HS range of motion value and the following combinations: HL, SU, SU/HS, and HL/F8. (Figure 4) Finally, we identified no significant difference between the CBW and the SU/HS or HL/F8 combinations or the SU/HL/F8 combination and the SU/HS or HL/F8 combinations. (Figure 4)

Eversion

The results of the repeated measures ANOVA for ankle eversion identified a significant difference among the 9 taping conditions. ($F_{8,152} = 6.83$, $p = .01$). The results of a Tukey post hoc test identified a significant difference between the no tape range of motion value and the SU/F8/HL taping combination as well as the CBW taping combination. The results of the Tukey post hoc test also identified no significant difference between the CBW and the SU/HS or HL/F8 combinations or the SU/HL/F8 combination and the SU/HS or HL/F8 combinations. Furthermore, the results of the Tukey post hoc test also identified no significant difference with any of the four independent components when compared to the no tape condition. (Figure 3)

Dorsiflexion

The results of the repeated measures ANOVA for ankle dorsiflexion identified a significant difference among the 9 taping conditions and the no tape value. ($F_{8,152} = 16.03$, $p = .01$). Results of the Tukey post hoc test identified a significant difference between the no tape range of motion and each of the four individual taping components: HS, HL, SU, and F8. (Figure 3) Of the four individual components heel-locks were responsible for the greatest restriction in dorsiflexion range of motion. Further significant differences were identified between the no tape range of motion value and the following taping combinations: SU/HS, HL/F8, SU/F8/HL, and CBW. (Figure 4) Finally, the results of the Tukey post hoc test identified no significant difference between the CBW combination and the HL/F8 or the SU/HS combinations. (Figure 4)

Plantarflexion

The results of the repeated measures ANOVA for ankle plantarflexion identified a significant difference among the 9 taping combinations and the no tape value. ($F_{8,152} = 29.78$, $p = .01$). Results of the Tukey post hoc test identified a significant difference between the no tape range of motion value and each of the following individual taping components: HL, SU, and F8. (Figure 3) Of the four individual components the heel-locks and figure-8's were responsible for the greatest reduction in plantarflexion range of motion. Significant findings were also identified between the no tape range of motion value and the following taping combinations: SU/HS, HL/F8, SU/F8/HL, and CBW. The results of the Tukey post hoc also identified a significant difference between the F8 and HS taping components. Finally, the results of the Tukey post hoc test identified no significant difference between the CBW combination and the HL/F8 or the SU/HS combinations. (Figure 4)

DISCUSSION

The primary purpose of this research was to establish which of the 4 individual components of the closed basket-weave ankle taping method (horseshoes, heel-locks, stirrups, figure-8's) were most effective in restricting ankle range of motion (eversion, inversion, dorsiflexion, plantarflexion).

Excessive plantarflexion and inversion are linked to the incidence of inversion ankle sprains^{2, 3, 20, 24}, thus it is important to restrict these motions when treating and preventing inversion ankle sprains with the use of adhesive tape. In this study we

established that inversion ankle range of motion was effectively restricted by all of the individual components except the horseshoe component. Of the three individual components that restricted inversion (stirrups, heel-locks, and figure-8's), the stirrups and heel-locks restricted the greatest degree of inversion. The results of plantarflexion closely followed those of inversion, with all of the individual components, except horseshoes, effectively restricting plantarflexion range of motion. However for plantarflexion the heel-locks and figure-8's were the most effective at restricting this motion. The motions of dorsiflexion and eversion were also assessed. The results showed that none of the four individual components were effective in restricting ankle eversion, while all four of the individual components were effective at restricting ankle dorsiflexion. Of the four individual components, the heel-locks were able to restrict the greatest amount of dorsiflexion. In summarizing these findings, the horseshoe component was found to be an ineffective component of the closed basketweave. Since it was not effective in reducing range of motion in any direction it could be removed from the closed basketweave taping method.

A secondary purpose of this research was to establish which of the taping combinations was most effective at restricting ankle range of motion. The results showed that the application of multiple components did restrict ankle range of motion when compared to the no tape values, but the application of more components did not necessarily make the tape application more effective. To date only one other study has evaluated the closed basketweave ankle technique in various combinations.²⁰ Their study only evaluated four combinations of the closed basketweave ankle taping method, whereas this study evaluated 8 variations.²⁰ They reported the taping combination

containing a basketweave, heel-locks, and stirrups was most effective in restricting ankle range of motion²⁰ whereas interpretation of our results showed the application of the two component combination (heel-locks and figure-8's) was just as effective as the three or more combination methods. It is important to note, the research by Rarick et al²⁰ did not contain an assessment of the figure-8 component of the closed basketweave.

Clinical Implications of Research

The closed basket-weave ankle taping method is one of the first taping procedures taught to athletic training students as a part of their educational curriculum. To date little research has been conducted to establish the reasoning behind using the closed basketweave ankle taping method. Clinically, as well as educationally, the findings of this research provides evidence as to the reasoning behind applying each of the components of the closed basketweave ankle taping method as well as which of the combinations is most effective. Through this research we established that the horseshoe component is ineffective in restricting ankle range of motion. The stirrups, heel-locks, and figure-8's each effectively restricted inversion, dorsiflexion, and plantarflexion. It was also found that adding more tape did not make a taping method more effective; rather, less tape with stronger components may make a more effective taping method.

Preventing and Treating Ankle Sprains

When taping is used to treat and/or prevent ankle sprains, inversion and plantarflexion are the directions the clinician is most concerned about limiting.^{2, 3, 20, 24} The results of this research are similar to the findings of multiple other studies that also

found the application of tape restricted range of motion when compared to a no tape.^{15,}
16, 18, 20, 25, 26

For inversion ankle sprains, the closed basketweave technique is used and emphasis is placed on pulling the components from medial to lateral. Since this study wanted to evaluate the ‘traditional’ use of the closed basketweave we also pulled the components from medial to lateral. This may provide reasoning for the lack of eversion range of motion being restricted by the individual taping components in this study. Additionally, only the three and four component combinations were able to effectively restrict eversion to any degree. Clinically, this is important, especially when clinicians use the traditional closed basketweave on all ankle sprains.

Few current taping procedures differentiate taping methods for inversion versus eversion ankle sprains. Most clinicians use knowledge gained through clinical experience to alter taping methods over time to fit various injuries in a way they see best. Athletic training educators often tell their students methods to alter the closed basketweave, such as pulling components from lateral to medial, versus the traditional medial to lateral method, as a way to treat eversion ankle sprains.

The closed basket-weave ankle taping method could be used to treat the more common inversion ankle sprains, but a comparable eversion taping method should also be developed. The results of this research show that the closed basketweave ankle taping method should not be used as a universal treatment/prevention of ankle sprains since its traditional method of application restricts motions associated with inversion ankle sprains. Rather than suggesting modifications to the closed basketweave in athletic training education it is suggested that a new eversion specific ankle taping be

developed. It is also recommended that the closed basketweave taping method be used solely for the treatment and prevention of inversion ankle sprains. By developing an eversion specific ankle taping method and including it in athletic training curriculum, the care of ankle sprains can be more specific to the injury thus improving overall care.

Limitations of this study

As with any research, this study included some limitations. During the planning phase of this research, all possible combinations of the four individual components were assessed for inclusion in this study. At that time the combinations deemed not clinically applicable were removed from the testing procedures. One combination that was removed was the SU/HL taping combination. Retrospectively it could have been tested as a second two component taping method and might have garnered interested information. Since our results showed the effectiveness of the stirrups in restricting inversion, it would be beneficial to assess the effectiveness of the SU/HL combination in further research.

Further limitations existed with the application of the tape. Though care was taken to maintain equality of tape throughout application by using only one researcher, tension may not have been equal from subject to subject either due to the integrity of each roll of tape or by unforeseen tension errors by the researcher.

Further research

This research focused on the immediate range of motion restriction following the application of a taping component or combination. Future research should be

conducted on the ability of identified taping combinations to withstand exercise. An important aspect of any taping method is its ability to withstand the physical activity associated with practice and competition. We identified that the heel-lock and figure-8 combination was effective at restricting range of motion immediately after application, but further research needs to be conducted to test the effectiveness of this taping method in withstanding practice and competition. We also suggest the development of an eversion specific taping method and therefore the development of such a method should be evaluated in future research.

Conclusion

The findings of this research indicate that the stirrups, heel-locks, and figure-8 components of the closed basketweave are each effective in restricting the ranges of motion associated with inversion ankle sprains. Furthermore, the findings establish that perhaps the full closed basketweave consisting of four components may no longer be the standard for ankle taping. Our results should lead to further exploration of whether the combination of heel-locks and figure-8's alone could serve as a gold standard in ankle taping for inversion injuries. At the very least this research has established the ineffectiveness of the horseshoe component and in stride proposed the removal of this unnecessary component.

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TABLES

Table 1: Procedures for Application of Taping Combinations

Tape Condition	Application explanation
	Each combination included 2 anchors: 1. Base of the gastrocnemius 2. Base of the MTP joint. Fill-in strips were also applied up to the lower ankle following the completion of each tape condition. (Figure 2.a)
Horseshoes	Begin by placing the tape on the medial midfoot then proceed around the distal Achilles tendon, over the lateral malleolus, and end on the lateral midfoot. Complete three times then anchor down with a single strip placed around the base of the gastrocnemius. Pull medial to lateral. (Figure 2.b)
Heel-locks	Lateral lock begins across the lace area of the midfoot with an angle toward the longitudinal arch, continue across the arch with an upward angle toward the lateral calcaneus; move around the posterior heel ending on the lateral aspect of midfoot. Medial lock begins at the medial lace area of the midfoot with an angle toward the lateral malleolus, then proceeds across the posterior heel, around the medial heel and ends on the medial lace area. Complete two medial and lateral heel-locks.(Figure 2.c)
Stirrups	Begins by placing tape on the medial side of the anchor strip then proceed down over the medial malleolus, under the plantar aspect of the foot, and up along the lateral malleolus finishing on the lateral side of the anchor strip. Complete three times then anchor down with a single strip placed around the base of the 5 th metatarsals at the styloid process. Pull medial to lateral. (Figure 2.d)
Figure-8's	Begins on the lateral malleolus, moves over the dorsum of the foot, under the foot on the medial side, back to the dorsum of the foot, then around the posterior aspect of the Achilles' tendon, ending back at the lateral malleolus. Complete two times.(Figure 2.e)
Stirrups & horseshoes in basket-weave	A stirrup is applied as described above followed by a horseshoe. This is repeated three times and is followed by an anchor at the base of the gastrocnemius anchor and at the styloid process of the 5 th metatarsal. This will result in the basket-weave pattern. (Figure 2.f)
Heel-locks & figure-8's in non-continuous fashion	Two medial and lateral heel-locks are applied followed by two figure-8's. (Figure 2.g)
Stirrups, figure-8's & heel-locks	Three stirrups with gastrocnemius anchor, followed by two medial and lateral heel-locks and figure 8's. (Figure 2.h)
Complete closed basket-weave	Three stirrups with an anchor at the gastrocnemius followed by three horseshoes with an anchor at the styloid process at the base of the fifth metatarsal followed by two medial and lateral heel-locks, finished by two figure-8's. (Figure 2.i)

Table 2: Taping Combination Range of Motion for Eversion, Inversion, Dorsiflexion, & Plantarflexion

Taping Combination	Eversion Range of Motion	Inversion Range of Motion	Dorsiflexion Range of Motion	Plantarflexion Range of Motion
No Tape	15.81° ± 3.81	32.11° ± 5.83	22.46° ± 5.82	28.41° ± 5.43
Horseshoe	14.77° ± 3.00	28.74° ± 6.23	20.07° ± 5.66*	26.95° ± 4.72
Heel-locks	13.83° ± 3.62	24.59° ± 6.60*†	18.71° ± 5.41*	24.81° ± 4.22*
Stirrups	15.37° ± 3.87	24.39° ± 7.72*†	19.79° ± 5.40*	25.56° ± 5.45*
Figure-8's	13.53° ± 4.06	26.37° ± 5.44*	19.12° ± 5.20*	23.63° ± 4.13*†
Stirrups/Horseshoes	13.45° ± 3.11	22.26° ± 6.16*†	18.97° ± 5.89*	25.19° ± 4.53*
Heel-locks/Figure-8's	13.47° ± 3.20	21.53° ± 6.34*†	17.03° ± 5.53*†	21.59° ± 5.23*†
Stirrups/Figure-8's/Heel-locks	11.33° ± 3.21*†	19.63° ± 7.29*†	16.84° ± 4.88*†	21.73° ± 3.98*†
Closed Basketweave	11.45° ± 3.44*†	19.41° ± 6.58*†	17.47° ± 4.54*†	20.66° ± 3.83*†

* Significant difference compared to no tape value

† Significant difference compared to HS value

LEGEND OF FIGURES

Figure 1: Ankle Electrogoniometer used in previous research to measure ankle range of motion

Figure 2: Taping conditions: the proper method for applying each of the taping conditions including anchors.

Figure 3: Individual Component range of motion values in degrees for inversion, eversion, dorsiflexion, and plantarflexion. *Indicates a significant difference when compared to the no tape value, † indicates a significant difference compared to horseshoe value.

Figure 4: Combination Results: range of motion values in degrees for inversion, eversion, dorsiflexion, and plantarflexion. *Indicates a significant difference when compared to the no tape value.

FIGURE 1: ANKLE ELECTROGONITOMETER

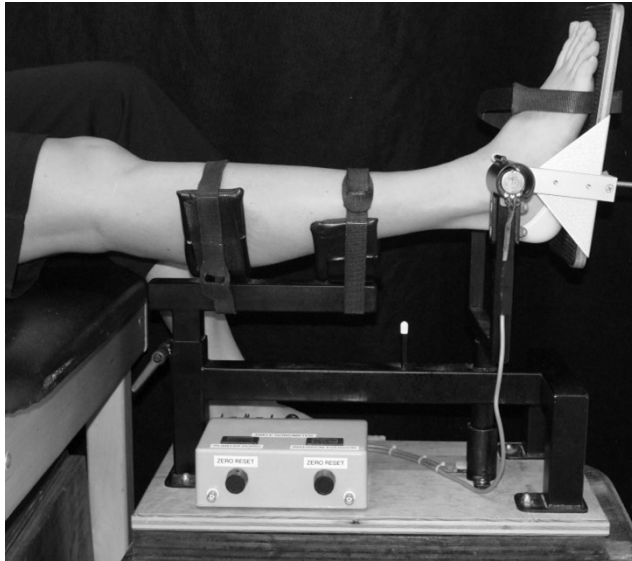


FIGURE 2.a
ANCHORS



FIGURE 2.b
HORSESHOES



FIGURE 2.c
HEEL-LOCKS



FIGURE 2.d
STIRRUPS



FIGURE 2.e
FIGURE-8's



FIGURE 2.f
STIRRUPS AND HORSESHOES



FIGURE 2.g
HEEL-LOCKS AND FIGURE-8'S,
NON-CONTINUOUS



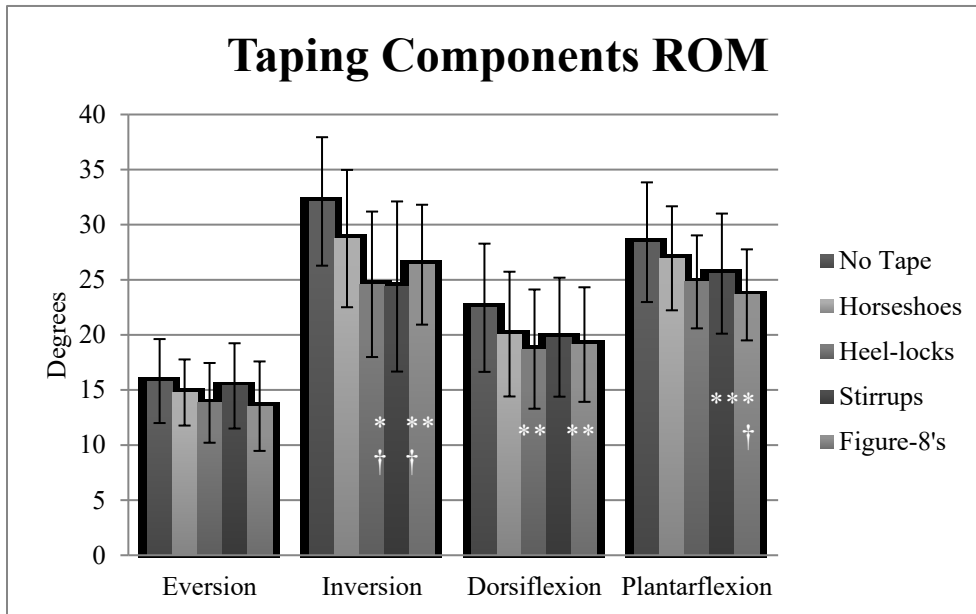
FIGURE 2.h
STIRRUPS, FIGURE-8'S, AND HEEL-
LOCKS



FIGURE 2.i
COMPLETE CLOSED
BASKETWEAVE



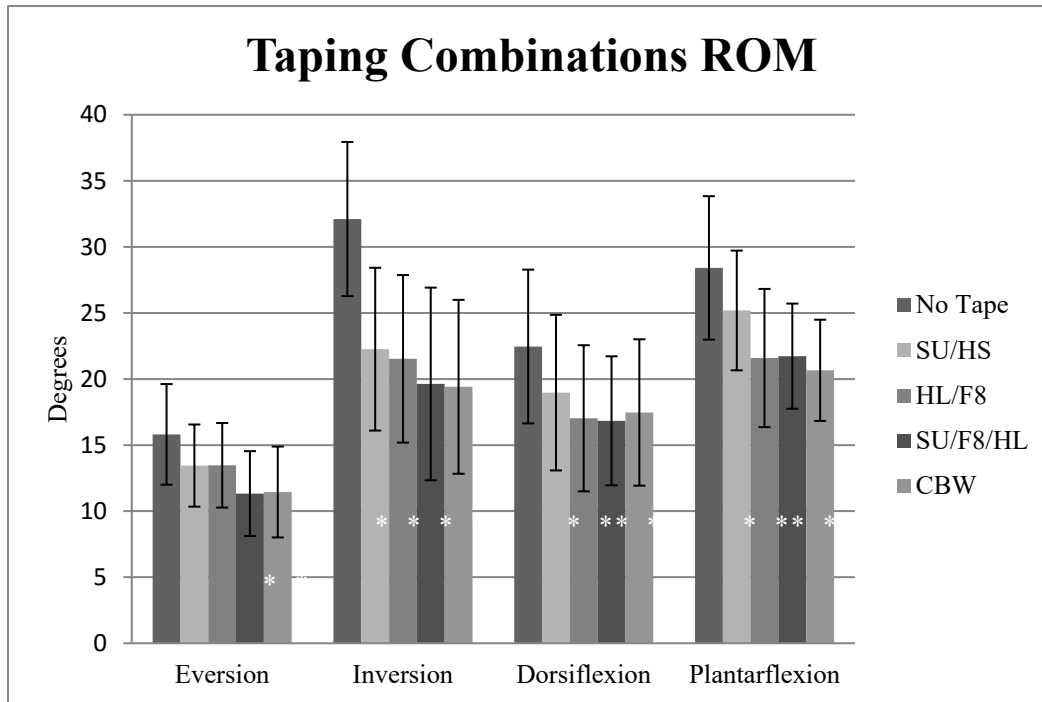
FIGURE 3: INDIVIDUAL COMPONENTS RESULTS



*Significant difference compared to no tape

†Significant difference compared to horseshoes

FIGURE 4: COMBINATION RESULTS



*Significant difference compared to no tape

APPENDICES

APPENDIX A

Operational definition

Assumptions

Delimitations

Limitations

Statement of the Problem

Independent Variable

Dependent Variable

Research Hypothesis

Operational definitions

1. Accepted trial: actively completing all four motions of the ankle range of motion (inversion, eversion, plantarflexion, and dorsiflexion) without the thigh or hip moving.
2. Closed Basket-weave: method of taping used to restrict ankle range of motion through the use of four components: stirrups, horseshoes, heel-locks, and figure 8's.
3. Dominant Leg: the leg the participant reports is used to kick a ball.
4. Figure-8's: component of the closed basket-weave that begins at the base of the metatarsals and wraps around the posterior heel in a fashion that resembles an 8.
5. Heel-locks: component of the closed basket-weave that begins on the dorsal side of the foot, moves under the foot and around the heel. There is a medial and lateral heel-lock.
6. Horseshoes: tape placed from medial to lateral beginning at the base of the first metatarsal proceeding behind the calcaneus and ending on the base of the fifth metatarsal.
7. Injury-free: having not sustained any acute injury to the ankle complex 6 months prior to testing that is currently resulting in inflammation, discoloration, reduced range of motion and/or reduced activity.
8. Lateral ankle sprain: an injury occurring to the lateral soft tissue structures as a result of surpassing normal range of motion for inversion resulting in an incomplete or complete tear of the lateral ligamentous structures (anterior talofibular ligament, posterior talofibular, or calcaneofibular ligament).

9. Physically active: partaking in cardiovascular activities for 30 minutes at least 3 times per week. (ie: running, cycling etc)
10. Stirrups: component of closed basket-weave that moves medial to lateral beginning on the medial side at the base of the gastrocnemius traveling under the plantar aspect of the foot then ending on the lateral side of the base of the gastrocnemius.

Assumptions

The following assumptions applied to this study:

1. Tape was applied by one investigator.
2. The tensile strength or tension among tape rolls was the same.
3. Participants were truthful when completing their medical history profile.
4. Participants were truthful in regards to their limb dominance.
5. Participants completed each active range of motion at maximal effort.
6. The time of day at which participants were tested did not affect gathered information.

Delimitations

The following delimitations will apply to this study:

1. Thirty participants were used.
2. The participants in this study were physically active individuals partaking in exercise three times or more per week.
3. The participants were between 18-25 years of age.
4. Participants were from a Midwestern Division 1 university.

5. Participants were injury free 6 months prior to testing and free of the following symptoms: discoloration, swelling, or decreased range of motion.
6. Participants were free of open wounds or abrasions in the testing area.
7. Taping and testing were conducted on the dominant leg.
8. The order in which components were applied was randomized.
9. Range of motion was measured for the motions of plantarflexion, dorsiflexion, inversion, and eversion.
10. Range of motion was measured without shoes and socks.
11. Ankle range of motion was measured immediately following application of tape.
12. Testing was completed in one day.

Limitations

The following limitations will apply to this study:

A Priori:

1. Due to human error the tape may not have been applied with consistent tension every time.
2. Placement of the subjects into subtalar neutral may have differed from subject to subject.
3. The tape may not have been applied directly to the subject's skin.
4. The material of the tape may have affected the performance of tape.

Statement of the Problem

With lateral ankle sprains being the most common injury sustained in athletics, use of prophylactic ankle taping is a common practice in athletic training. Though there are many taping methods used to stabilize the ankle through range of motion restriction, the most common method used is adhesive ankle tapings. The most widely used and accepted method of adhesive ankle restriction is the closed basket-weave. Though this method is the most common, the research regarding the actual effectiveness of the method focuses mainly on the taping procedure as a whole. This study set out to dissect the closed basket-weave into its individual components (stirrups, horseshoes, figure-8's, and heel-locks) and test the effectiveness of each to decide which components are necessary to accomplish the task of restricting range of motion. Additionally this study will try to establish which combination of the closed basket-weave components is the most effective method for supporting and preventing injuries to the lateral ankle complex.

Independent Variable

One independent variable will be evaluated in this study:

1. Individual tape elements at 10 levels:
 - a. Beginning no tape
 - b. Horseshoes only
 - c. Heel-locks only
 - d. Stirrups only
 - e. Figure-8's only
 - f. Stirrups and horseshoes in basket-weave formation

- g. Heel-locks and figure-8's in non-continuous fashion
- h. Stirrups, figure-8's and heel-locks
- i. Complete basket-weave
- j. Ending no tape

Dependent Variable

Four dependent variables were evaluated in this study:

- 1. Plantarflexion range of motion (°)
- 2. Dorsiflexion range of motion (°)
- 3. Eversion range of motion (°)
- 4. Inversion range of motion (°)

Research Hypotheses

- 1. There will be a significant decrease in range of motion as more components are applied in combination.

Statistical Hypothesis

- 1. Ankle range of motion: $H_A: \mu_c \neq \mu_{HS} \neq \mu_{HL} \neq \mu_{SU} \neq \mu_{F8} \neq \mu_{SU+HS} \neq \mu_{HL+HS} \neq \mu_{HL+F8noncont} \neq \mu_{SU+F8+HL} \neq \mu_{completeBW}$

Null Hypothesis

1. Ankle range of motion: $H_A: \mu_c \neq \mu_{HS} \neq \mu_{HL} \neq \mu_{SU} \neq \mu_{F8} \neq \mu_{SU+HS} \neq \mu_{HL+HS} \neq \mu_{HL+F8noncont} \neq \mu_{SU+F8+HL} \neq \mu_{completeBW}$

APPENDIX B

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

This literature review will cover the anatomy of the talocrural and subtalar joints, etiology of lateral ankle injuries, role and purpose of adhesive athletic taping methods in ankle injuries, range of motion restriction immediately following ankle tape application, and range of motion values for ankles taped following exercise.

Ankle anatomy

The ankle complex is comprised of four bones: the talus, calcaneus, tibia, and fibula. Together these bones form three distinct bony articulations including: the talocrural joint, the subtalar joint, and the distal tibiofibular syndesmotic joint.^{1,2}

The talocrural joint, also called the tibiotalar joint, is formed by the articulations that occur between the dome of the talus and the medial and the lateral malleoli of the tibia and fibula.¹ The talus plays a key role in the talocrural joint acting as the connection between the foot and the lower leg. The talocrural joint is classified as a “hinge joint” and allows for the motions of plantarflexion and dorsiflexion.¹

Due to the amount of motion occurring at the talocrural joint it is essential to maintain stability in conjunction with motion. The talocrural joint is able to achieve this balance through the presence of crucial ligamentous support. Primary support of the talocrural joint is provided by the joint capsule, the anterior talofibular ligament, posterior talofibular ligament, and calcaneofibular ligament laterally, and the deltoid ligament medially which consists of the talonavicular, tibiocalcaneal and tibiotalar ligaments.^{1,3-7} The anterior talofibular ligament, which is the smallest of the three ligaments at an average of 20

mm long and 2mm thick, runs from the talus to the fibula.^{4-6, 8} The posterior talofibular ligament attaches on the talus and then to the fibula and then blends with the anterior talofibular ligament and the lateral joint capsule.^{4, 5} The calcaneofibular ligament is the strongest and thickest of the three lateral ligaments at an average of 20mm long and 3mm thick and it attaches on the calcaneus and the distal fibula.^{4, 5, 8} Each of these ligaments is important in preventing unwanted excessive motion within the lateral ankle complex.^{3, 6} The anterior talofibular and the posterior talofibular ligaments are responsible for limiting excessive inversion while the calcaneofibular ligament is responsible for limiting excessive supination.¹ A ligament often left unaccounted for in ankle injuries is the inferior tibiofibular ligament which extends from the tibia obliquely downward and lateral toward the medial distal fibula.⁴

Also aiding to limit excessive lateral motion within the talocrural joint is the musculotendinous support provided by the peroneal tendons, also known as the fibular tendons.^{1, 3} Peroneal longus originates laterally on the proximal two-thirds of the fibula and runs medially on the plantar aspect of the foot to insert on first metatarsal and the medial cuneiform.³ Positioned anteriorly to peroneal longus, the peroneal brevis muscle originates laterally on the distal two-thirds of the fibula and inserts on the base of the fifth metatarsal.³ Providing further lateral support and maintaining the location of the peroneal tendons is the superior peroneal retinaculum which lies over the tendons.³ The contraction of the peroneal longus, peroneal brevis, and peroneal tertius tendons provide the talocrural joint with dynamic stability. Excessive stretching of these structures, either acutely or chronically, can lead to a sense of instability within the ankle joint.¹

The subtalar joint, also known as the talocalcaneal joint, is comprised of articulations between the talus and the calcaneus and is comprised of two joint cavities.¹ The posterior subtalar joint is made up of the inferior talus and the superior posterior calcaneus, whereas the anterior subtalar joint is comprised of the head of the talus, the sustentaculum tali, and the proximal portion of the navicular.¹ The subtalar joint allows for the motions of eversion and inversion.

Palpation of the talus is important in the process of establishing subtalar neutral within the subtalar joint. Establishing subtalar neutral first begins by palpating the dome of the talus.⁹ Once the dome is felt the practitioner will move the foot into inversion and eversion where by which they will establish equality of the dome on the medial and lateral sides thus establishing talonavicular congruency.¹⁰

As with the talocrural joint, ligamentous support is vital in preventing unwanted excessive motion of the subtalar joint, which could potentially lead to injury. Weak support for the subtalar joint comes from the interosseous ligaments and the cervical ligament.¹ Together these two ligaments restrict excessive inversion and eversion.¹

Another, less commonly injured joint of the ankle is the distal tibiofibular syndesmodic joint.² The syndesmodic joint is a joint that is present between the tibia and fibula and runs the length of the two bones.² Maintaining the alignment of the tibia and fibula are three ligaments including the anterior inferior tibiofibular ligament, the posterior inferior tibiofibular ligament, and the interosseous ligament.² These ligaments are important in limiting external rotation of the tibia.²

Ankle injuries and etiology

In the high physical stress environment of athletics, the stability of the ankle joint is often pushed to the extremes. As discussed previously, the ankle maintains stability through the congruity of the articulating surfaces as well as ligamentous and muscular support. Should any of these areas of support be damaged an ankle injury is likely to occur.¹

Ankle injuries are among the most common injuries sustained by those participating in athletic competition.^{6, 11-16} Athletes of all levels have reported suffering from lateral ankle sprains including high school, college, and professional.^{11-13, 16, 17} During the 2004 Olympic games in Athens a total of 624 ankle injuries were reported from both men's and women's sports.¹² Five hundred and twenty-five of the injuries reported were soft tissue injuries of which there were a reported 138 ankle sprains, making them the second most common injury reported.¹² Of the 138 ankle sprains reported 100 were sustained by female athletes versus 38 sustained by male, though some studies suggest the incidence for ankle sprains is not affected by gender.^{12, 13}

In collegiate field hockey athletes, between 1988 to 2003, 60% of practice injuries and 40% of game time injuries occurred in the lower extremities.¹¹ Fourteen percent of total game injuries and 15% of total practice injuries resulted in ankle ligament sprains.¹¹ When recording ankle injuries over two competitive years, Woods et al¹⁶ found that of all ankle injuries the highest percent were ankle sprains with 77% of ankle sprains being lateral ankle sprains.¹⁶

During the 2005-2006 competition year in 100 high schools over 300,000 ankle injuries were reported which accounted for 22.6% of the total injuries sustained during that year.¹³ Sports that involved high amounts of cutting and quick changes in direction, such as

boys' and girls' basketball, football, soccer, and volleyball, presented with the highest incidence of ankle injuries.¹³ Nelson et al¹³ found that of the ankle injuries reported, 83.4% were diagnosed as ligament sprains with incomplete tears, followed by fractures (5.2%), ligament sprains with complete rupture of tissues (4.0%), and lastly contusions (2.0%).

The most common athletic ankle injury is the lateral or inversion ankle sprain resulting from incomplete or complete ligament disruption.^{1, 4, 7, 14} An averaged seven year post-surgical follow-up of 100 patients, ages 12 to 47, with lateral ankle sprains revealed that 59% of the injuries were sustained in some form of athletic participation with the remaining ankle injuries sustained in traffic accidents and work-related or household accidents.¹⁸ Of the athletic related ankle injuries reported the majority of these occurred while playing volleyball.¹⁸ The most common mechanism of injury for this is that of excessive inversion with plantarflexion and internal rotation.^{4, 5, 14, 19} Such excessive motion often occurs due to unequal surfaces in competition and practice fields, as well as athletes stepping on one another or equipment.¹⁴

When an athlete sustains a lateral ankle sprain, the lateral ankle complex surpasses the mechanically allowed motion for inversion resulting in an excessive stretching of the lateral ligamentous structures.¹ The damage caused by excessive motion disrupts the ligamentous support of the lateral ankle complex and creates laxity or looseness within the joint. The extent of the damage to the ankle's structures is dependent on the amount of force and the direction in which it was applied to the ankle.⁷

When lateral ankle sprains occur they most often disrupt the integrity of the anterior talofibular ligament (ATFL) because it is the smallest and weakest of all lateral ligaments.^{4, 5} The posterior talofibular ligament is usually the next ligament to be injured in lateral ankle

sprains due to its conjunction with the ATFL in blending with the ankle's joint capsule.⁴ In severe lateral ankle sprains the calcaneofibular ligament may also be disrupted, though it is not common for it alone to be damaged in lateral ankle sprains.^{4, 18} In moderate ankle sprains it is also possible for there to be a disruption of the ankle's joint capsule due to the attachment of the capsule and the anterior and posterior talofibular ligaments.⁴

Lateral ankle sprains are most commonly medically classified in grades, either grade I, II, or III.⁸ Though degree and order of ligaments injured can vary, most often a grade I ankle sprain is classified as microscopic damage of the anterior talofibular ligament and is reported to present with little to no swelling, pain, and no loss of function.⁸ A grade II is then classified as a complete rupture of the anterior talofibular ligament and an incomplete tear of the calcaneofibular ligament that presents with limited range of motion, pain, swelling, mild laxity, and point tenderness.⁸ And lastly a grade III lateral ankle sprain is classified as one that results in a complete tear of both the anterior talofibular and the calcaneofibular ligaments.⁸ A grade III lateral ankle sprain results in obvious deformity, pain, excessive laxity, and swelling.⁸

When an ankle sprain occurs mechanical instability will often occur due to the changes in the anatomy of the ankle at the time of injury.¹ If not cared for correctly mechanical instability can lead to further injuries such as synovial problems, degenerative joint disease, impaired arthrokinematics, and chronic instability.¹

The extent of the damage to the ankle joint directly affects the amount of participation time the athlete loses due to injury. Of 326,396 ankle injuries reported throughout one competition year at the high school level, 51.7% of them resulted in less than 7 days missed of practice/competition and 33.9% resulted in 7-10 days of missed time.¹³ In

total, the reported ankle injuries resulted in over 2 million days lost from practice and/or competition.^{13, 20}

Prophylactic Tape Application

Prophylactic taping methods are the common method of care for athletes with ankle stability issues.^{5, 20-22} The method and the type of tape varies among clinicians based on personal preference.^{5, 21} Adhesive taping methods are used when an athlete has sustained an injury to the ankle complex which requires extra stability.^{5, 22}

Purpose and role of tape application

Prophylactic ankle taping methods are used to reduce risk of injury or re-injury by providing mechanical support and/or improving ankle proprioception.^{5, 22, 23}

It was found that adhesive tape application can aid in protecting against injury or further injury by providing mechanical support and/or creating a mechanical block against unwanted forces.²² The application of adhesive tape in a particular order decreases the “sprain mechanism”²² which is the unwanted motions of inversion and plantarflexion^{19, 22} that are most commonly associated with lateral ankle sprains.^{4, 14, 19} Rarick et al¹⁹, tested prophylactic tape application as a mechanical restraint against the unwanted forces of inversion and plantarflexion and found that tape application does significantly provide restraint against these unwanted forces.¹⁹

The use of adhesive tape to increase a person’s ankle proprioception, or joint awareness, is yet another use of tape discussed by various authors.²²⁻²⁴

Despite numerous studies supporting the previous claim, further studies have shown tape can inhibit one's ability to detect unwanted inversion or eversion movements.²⁵ It was reported that when taped was applied participants with recurrent ankle sprains had a decreased ability to detect the unwanted, often injury-producing movements in the inversion/eversion plane.²⁵

For some acute ankle injuries adhesive ankle taping methods may be used as a compressive force to aid in the reduction and control of edema.^{5, 21}

Preparation for Tape Application

Prior to the start of application of any taping method, it is vital to insure the athlete or individual's ankle receiving the taping is free of open wounds or abrasions. To prepare the ankle for taping, either remove the hair through shaving^{26, 27} or use alcohol to remove dirt and debris to ensure a tight hold. Next apply an adhesive tape spray to the ankle followed by two heel and lace pads and a thin covering of foam pre-wrap material.^{8, 27-31} To begin the taping procedures 1 1/2 inch adhesive tape is most commonly used.^{20, 26, 31, 32} Investigators next apply anchor strips.^{8, 28, 30, 31, 33}

Many methods of ankle taping have been employed in the past and this literature review focus will remain on the closed basket-weave taping, the subtalar sling taping, fibular repositioning taping methods.

Closed Basket-weave taping method

The closed basket-weave taping method, also known as the modified Gibney closed basket-weave taping method, is the most commonly used taping method of ankle range of

motion restriction in athletics.^{19-21, 29, 30, 33-36} The closed basket-weave taping is a method of ankle restriction that uses stirrups and horseshoes^{19, 26, 31, 36} overlapping one another to create the basket-weaved effect followed later by figure-8's and/or medial and lateral heel-locks^{19, 26, 31, 36}. Most commonly 1 ½ inch adhesive tape is used to complete the closed basket-weave taping method.^{20, 26, 31, 32} A stirrup is created by taking a strip of adhesive tape and traveling from the medial aspect of the base of the gastrocnemius, moving underneath the base of the calcaneus and ending on the lateral aspect of the base of the gastrocnemius.³¹ A horseshoe begins by placing the strip of tape on the base of the first metatarsal then traveling around the posterior aspect of the calcaneus and finally ending at the base of the fifth metatarsal.³¹ The final components of the closed basket-weave taping method are the figure-8's and heel-locks.^{29, 31, 33, 34} A heel-lock is a component of the closed basket-weave that begins on the dorsal side of the foot, moves under the foot and around the heel and attaches on the opposite side as it was begun. When applying this component in the closed basket-weave there is a medial and lateral heel-lock.^{29, 31, 33, 34} The figure-8 is a component of the closed basketweave that begins on the lateral malleolus, moves over the dorsum of the foot, under the foot on the medial side, back to the dorsum of the foot, then around the posterior aspect of the Achilles' tendon, ending back at the lateral malleolus.³⁷

Subtalar Sling taping method

The subtalar sling was developed from many aspects of the Gibney taping method which was developed in 1895.^{24, 26} The purpose of the subtalar sling is to position the subtalar joint in a way that limits the displacement of the hindfoot inward.²⁴ Proper application of the tape

resists varus displacement of the ankle joint thus reducing the risk of an inversion ankle sprain.²⁸

The subtalar sling differs from other ankle taping methods in that adhesive cloth tape is not used throughout its entirety. Rather some clinicians craft the sling component using a form of elastic tape.²⁶⁻²⁸ To properly apply the sling portion the tape is placed on the plantar aspect of the forefoot of the foot and then wrapped around the lower leg.²⁷

Application of the sling portion of the subtalar sling is vital to proper performance. A more anteriorly placed sling results in more motion being restricted, but it tends to be less comfortable for the athlete.²⁴ Whereas the more posterior the sling, the more comfortable it is, but the less restrictive it is.²⁸ It is important to determine a midway point between of comfort and restriction to have positive effects and comfort.²⁴

Many components of the closed basket-weave taping method are replicated in the subtalar sling method including the use of horseshoes and stirrups.²⁶⁻²⁸ Prior to the application of the sling component, figure-8's and heel-locks are applied as well.²⁶⁻²⁸ The subtalar sling in conjunction with the components of the closed basket-weave is reported to further reduce the risk of inversion ankle sprains when compared to the closed basket-weave alone.²⁶ The use of many components of the closed basket-weave shows the overlap that exists with prophylactic taping methods which are continually being taken and improved upon.

Fibular repositioning taping method

A less common taping method, the fibular repositioning taping, is used to position the fibula in such a way that reduces the risk of an ankle sprain.³⁸ Unlike the two methods

earlier discussed, the fibular repositioning taping contains only one component which is two 20 centimeter strips of non-elastic tape that begins at the lateral malleolus, wraps around posteriorly, and ends on the medial malleolus.³⁸ It was found that of 125 subjects wearing the fibular repositioning tape sustained only two ankle injuries while there were nine reported injuries from those without the taping.³⁸ With this taping method being relatively new, further research is still needed to test the effectiveness.

Range of Motion Restriction Immediately Following Tape Application

Though some controversy is present regarding the effectiveness of adhesive tape during athletic participation, studies have shown that adhesive tape, immediately following application, is able to successfully limit ankle range of motion.^{30, 39, 40 41, 42}

When looking at four variations of the current closed basket-weave components, basket-weave, basket-weave with heel-lock, basket-weave with stirrup, basket-weave and stirrup and heel-lock, Rarick et al¹⁹ found the greatest amount of range of motion restriction with the basketweave, heel-lock, and stirrup combination. It was also established that each of the four variations were successful in restricting a significant amount of range of motion when compared to no-tape values.¹⁹

A comparison of the closed basket-weave ankle taping method against other prophylactic methods showed that the ankle taping was capable of restricting range of motion within the ankle when compared to the ankles in an untaped situation.³⁰ Further research has also concluded that application of the closed basket-weave is capable of restricting ankle range of motions of inversion and eversion a significant amount, up to 62% in some cases, when compared to pre-application values.^{40, 42} When comparing the subtalar

sling ankle taping methods to the DonJoy Ankle Ligament Protector values showed that immediately following application, the subtalar sling taping method restricted a greater amount of motion in comparison to the ligament protector.²⁸

Manfroy et al⁴¹ found that immediately following the application of the closed basket-weave ankle taping method the amount of inversion force participants were able to withstand significantly increased when compared to untaped values. Similar results reported up to a 72% increase in inversion force resisted with the application of tape.⁴² These studies suggest that the properties of adhesive tape when applied to the ankle are able to restrict range of motion. This ability to restrict range of motion is important in maintaining an optimal healing environment for athletes attempting to return to play following an ankle injury.

Range of Motion Restriction of Applied Tape Following Exercise:

Though there are many benefits to taping the ankle, the cloth-like properties of elastic athletic tape can be negatively affected by various factors such as exercise which may result in a decrease in the range of motion restricted.^{28, 30, 42, 43} Some argue that physical activity can reduce the amount of motion the tape is able to restrict thus rendering it ineffective.^{24, 28, 30} It has been proposed that the increase in ankle range of motion while taped could potentially be a result of the increase in soft tissue temperature that occurs during exercise.²⁸ Prophylactic taping methods have been successful in providing an immediate reduction in range of motion^{30, 39-42} but have lost 21-40% of its restraint within ten minutes of physical activity.³⁰ Some have reported significant reductions in restraint up

to 60%¹⁹ following exercise while other researchers have found that tape continues to restrict range of motion when compared with pre-taped values.^{29, 30, 41}

Many studies have shown that exercise does result in a decrease in the amount of range of motion restricted by tape at the ankle complex.^{20, 28-30, 33, 34, 41, 42, 44} Despite the decrease in ankle range of motion restriction, the tape is still effective in limiting excessive motion commonly present leading to a severe ankle injuries.^{24, 30, 43, 45} It was reported that following 10 minutes of physical activity the prophylactic taping restricted less motion than pre-exercise values but it was still successful in providing support to the ankle when compared to pre-exercise values.^{19, 46} Though the amount of range of motion restricted throughout exercise was less for the ankle taping, compared to other devices, it was still able to restrict motion when compared to values prior to tape application.^{39, 47}

A comparison of various prophylactic ankle devices before and after exercise concluded that following the exercise protocol, of the three tested restraint systems, the tape restricted the least amount of motion pre- to post-exercise.³⁰ When comparing a rigid orthotic to a taping method throughout the duration of a volleyball game, investigators found that range of motion restriction continued to decrease at 20 minutes, 60 minutes, and at the completion of the game for the ankle taping.²⁹ Despite the decrease in motion restriction, the range of motion values for the tape never reached those of the initial, no-tape, values.²⁹ These results suggest that despite the decrease in restricted motion over time, the application of a prophylactic ankle taping method will still be effective at reducing range of motion.

Following completion of the established exercise protocol, the subtalar sling ankle taping method rendered range of motion values equivalent to that of the rigid device yet the loss of restricted motion was not enough to render the taping method entirely ineffective.²⁸

A comparison between various orthodic bracing techniques and the closed basket-weave over an extended period of exercise determined that taping method was unable to maintain its prior restriction amount although it was still restricting range of motion when compared to pre-application values.⁴⁰ This study also found that the other prophylactic bracing devices used also had a decrease in range of motion restriction as time progressed revealing that no device is capable of maintaining a perfectly restricted amount of motion.⁴⁰

Conclusion

The preceding literature review shows that with lateral ankle sprains being ever so prevalent in athletics discovering a method of treatment and or prevention of these issues is important. This evidence suggests that in current literature there is not an established a gold standard for a method to restrict ankle range of motion. Though evidence has shown that exercise can be detrimental to the range of motion restricted by adhesive taping methods, it has also shown the tape is capable of maintaining some level of range of motion restriction. So although the tape may not maintain its restriction it is still effective to some degree. Currently the best method is selected based on athlete preference and supplies available to the clinician.

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